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ROYAL ARMAMENT RESEARCH AND DEVELOPMENT ESTABLISHMENT

EXPLOSIVES DIVISION

R.A.R.D.E. MEMORANDUM 38/70

Development of the Detonator Electric CC No. 1 for use in the Bomb Cluster HE 600lb No. 1 Mk. 1 (BL 755) [~~C~~]

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Fort Halstead
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[redacted]

December
1970

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RARDE Memo 38/70	Development of the detonator Electric CC No 1 for use in the Bomb Cluster HE 600 lb No 1 Mk 1 (BL755) J Wilby, M G Brown, J C Leman	RESTRICTED

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6

R.A.R.D.E. MEMORANDUM 38/70

3

Development of the Detonator Electric CC No.1 for use in the Bomb Cluster HE 600lb No.1 Mk 1 (BL 755) (C)

5 December 1970

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Summary

The Detonator Electric CC No.1 has been characterised in terms of both its electrical sensitivity and explosive performance and shown to be suitable for use in the bomblet fuze train in the Bomb Cluster HE 600lb No.1 Mk 1 (BL 755).

Approved for issue:

D. F. Runnicles, Principal Superintendent, 'E' Division

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CONTENTS

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1. INTRODUCTION

Existing proximity fuze systems, employing a conducting composition (CC) igniter to initiate a flash receptive RZY detonator, can give unsatisfactory performance due to hydrolysis of the lead-azide increment in the unsealed detonator. For this reason E1 Branch RARDE has given priority to the development of conducting composition detonators for new fuzes and S & A mechanisms; these devices will considerably simplify the explosive train and, being more effectively sealed, minimise the hydrolysis problem.

The Detonator, Electric CC No 1, described in this memorandum, is the first conducting composition detonator to find a Service application and was developed specifically for use in the piezo-electric fuzes of the bomblets in the Bomb Cluster HE 600lb No 1 Mk 1 (BL755). The new detonator is a modification of the well established N8 igniter (Refs 1 and 2) shown at Fig 1 in which the conducting composition of lead styphnate/graphite has been replaced by one of lead azide/graphite followed by an increment of RDX.

2. DESIGN CRITERIA

In the absence of a formal technical requirement RARDE/E3 advised the bomblet design authority, Messrs Ether Engineering Ltd (EEL), that only a conducting composition type of initiator would have sufficient electrical sensitivity for reliable functioning from the small piezo crystal envisaged. As work on an experimental CC detonator was at an advanced stage and as the cost, space and long term reliability benefits of using such a device, rather than a CC igniter followed by an RZY detonator, were attractive it was agreed that RARDE would develop a CC detonator for BL755. Reliable functioning, when used in conjunction with the EEL piezo crystal and gap assembly, after environmental and rough handling conditions broadly based on the overall weapon specification (Ref 4) was an essential requirement.

As CC igniters were always fired from capacitor discharge circuits normal practice at RARDE had been to establish the energy sensitivity by statistically determining the 'all-fire' and 'no-fire' charging voltages for the capacitance to be used in the fuze application. The system in BL755 was a departure from normal practice since the firing stimulus was to be provided by a mechanically deformed piezo crystal. For this reason EEL was requested to state a realistic capacitance which would enable RARDE to perform a full statistical analysis using a normal condenser-discharge circuit. Initially the effective capacitance of the piezo crystal was defined as 1000 pF but this was subsequently reduced to 500 pF when the crystal size was changed; the Ordnance Board trials, described in this memo were based on this latter figure. A further reduction of crystal size led to the effective capacitance being redefined as 220pF and on the basis of trials conducted by EEL the minimum energy available from the fuze is 64 μJ. In spite of the radical reduction in output energy since first inception the results obtained in the trials to be described indicate that the detonator is sufficiently sensitive to give reliable functioning with the current fuze.

3. DETAILS OF DETONATOR DESIGN

3.1 General

Fig 2 shows the components used in the manufacture of the Detonator, Electric, CC No 1. These components are manufactured at ROF Blackburn where the empty store is assembled as follows:

The pole-piece (B) is inserted into the body (A) below the fibre spacing washer (C) which constitutes the electrode seperator in the body return electrical system. The shaped fibre washer (D) is formed, from a blank, on the pole piece and the open end of the body is turned over under a dead load of 1250 ± 250lbF; the fibre washer serves the purpose of absorbing elastic recovery on removal of the turnover load and insulating the body from the pole piece.

Filling of the two explosive increments is carried out at ROF Chorley. Closure is achieved by pressing home the paper disc (F) and the shaped cup (E). The paper disc was introduced between the closing cup and the charge to wipe off any explosive adhering to the walls of the detonator, thus reducing the risk of frictional initiation when the closing cup is pressed home; experiments showed that the paper disc had no deleterious effect on the explosive output of the device.

The detonator is sealed at both ends using RD1177 varnish; the varnish at the pole piece end is applied before filling.

Fig 3 shows the filled detonator. For safety reasons the diameter of the detonator was made greater (0.28in. instead of 0.24in.) than the igniter to obviate the possibility of inserting it in a housing designed to take an N8 igniter.

Electrical contact to the detonator is achieved by connections to the pole piece and the body and application of an electrical stimulus causes current to flow across the 8 mil annular gap through the conducting paths formed by contacting graphite particles.

3.2 Materials

3.2.1 Body Material

Some difficulty was encountered with the conflicting requirements for brass which would not crack at the turnover and which would be reasonably easy to machine in mass production. The 'soft' brasses such as CZ123 are not prone to stress corrosion cracking at the high stress region of the turnover but are difficult to machine, whilst the harder brasses such as CZ112 and CZ121 give a good machined surface finish relatively easily but are very prone to stress corrosion cracking.

Trials at RARDE, D2 Branch, employing a mercurous nitrate technique established that 'turnovers' in both CZ112 and CZ121 brasses exhibited cracks after 24 hours; it was also confirmed that no cracks could be induced in CZ123 brass.

RARDE, D3 Branch has examined the susceptibility of the highly stressed brass at the turnover to stress corrosion cracking in the presence of atmospheres which the detonator might conceivably experience in Service. With CZ 121 brass it was noted that the formation of cracks was accelerated in the presence of acetic acid, formic acid, ammonia and sulphur dioxide, whilst no cracking was induced in CZ 123 brass.

It was suggested that creep rupture might be avoided with CZ 121 by the introduction of a suitable heat treatment operation after machining. However, after extensive trials by ROF Blackburn and RARDE/D2, the conclusion was reached that whilst heat treatment of the machined bodies at 550°C gave satisfactory results on turnover it introduced scaling of the surface which would need to be cleaned off. The cost of this descaling process would be greater than the increase in tooling costs involved in producing empty assemblies from a softer brass and consequently CZ 123 brass has been adopted for production of the Service store.

3.2.2 Plating

The body, pole piece and closing cup (as with the N8 igniter) are plated with 0.3 mil silver to Defence Guide 8. As the piezo-electric fuze achieves relatively high voltages there was no need to introduce the gold plating necessary to give good electrical contact in lower voltage systems and this led to a considerable saving in unit cost.

3.3 Filling

3.3.1 First Increment - Conducting Composition

3.3.1.1 Explosive Component

The explosive selected was lead azide RD1339 as this has flow properties which minimise the probability of segregation in the conducting composition. The mean particle size of this material is smaller than that of the normal service lead azide; after precipitation it is passed through a sieve to BS60, which removes any agglomerates of particles.

Lead azide was used in preference to silver azide when it was found that thermal cycling resulted in a marked increase in resistance, and hence electrical energy sensitivity, of devices using silver azide, whereas detonators with lead azide remained stable. Since the detonator is sealed hydrolysis problems associated with lead azide were not anticipated.

3.3.1.2 Conductive Components

In common with all other CC devices the conductant used is Dohm's Air-Floated Graphite (DAF3) which has a mean particle size of approximately $9 \mu m$.

3.3.1.3 Electrical Characteristics

Consideration of the generally accepted 'modus operandi' of CC devices (see Ref 2) indicates that the electrical energy sensitivity is related to resistance of the device the lower the electrical energy required for initiation.

However, increased sensitivity can only be obtained at the expense of reproducibility, ie the 'all fire' and 'no fire' energy levels diverge as sensitivity is increased.

Parameters which affect resistance are: internal surface finish, electrode separation, graphite particle size, percentage of graphite in the mix and the consolidation load; having established that a surface finish of 32 μ in. CLA gave acceptable results, and using the DAF3 graphite common to all CC devices, only the last two parameters were considered.

Based on preliminary work with the piezo electric fuze, at EEL, it was established that the required reliability could be obtained using a detonator of about 15 ohms and the initially specified resistance range was from 13 to 18 ohms. However, this narrow range led to an unacceptably high rate of rejection at ROF Chorley despite the use of the constant resistance press. The resistance range was therefore increased to 10-30 ohms which permitted the use of a dead load press.

3.3.1.4 Specification of first increment

This is lead azide, RD 1339, with approximately 4 per cent by weight of DAF3 graphite, the exact graphite percentage being adjusted to give the required resistance range of 10 to 30 ohms.

The charge weight is 50 $\pm$ 5 mg consolidated at a deal load in the range 250-325lbF.

3.3.2 Second increment

RDX was chosen for this increment in preference to CE as it was found that the spread in firing times was greater with the latter although the means were similar.

The RDX used is RD1347 to Spec. TS564 and the charge weight of 45 $\pm$ 5mg is consolidated to a stop at a dead load not exceeding 325lbF, see Fig 3. The spacing between the top of the RDX and the mouth of the detonator was originally thought to be critical in relation to explosive output but experimental studies proved that this was not the case and the dimension currently specified is 35 + 0 - 8 mil.

The 5 mil paper washer and the 8 mil silver plated closing cup are inserted under a dead load not exceeding 325lbF.

3.4 Sealing

3.4.1 Pole piece end

The pole piece end is sealed before filling by applying RD1177 around the crimped joint with the mouth end of the detonator under a low vacuum of approximately 5in of Hg; in this way varnish is drawn into the gap between the pole piece and the body and to a limited extent impregnates the fibre insulation washer giving an effective seal.

3.4.2 Mouth end

The mouth end was originally sealed by applying a drop of varnish RD 1177 to the closing cup and leaving to set for 48 hours, This method of application was difficult to control and led to a variation in meniscus thickness which was found to cause unacceptably large differences in the explosive output of the detonators. The results of trials which demonstrate this effect are shown in Fig. 4.

To overcome this problem the present technique of spin varnishing was adopted; after application as described above excess varnish is removed by rotating the detonator at 5000 rpm. This process ensures that the meniscus thickness is kept to a minimum and encourages the penetration of varnish into areas which must be sealed.

3.5 Handling, Storage and Transport

In the past CC igniters had shorting clips fitted to ensure a short circuit between the pole piece and the body whilst being handled and transported. Such shorting clips have been found to vary in quality so that it was difficult to guarantee effective spring contact with the pole piece. In fact accidents have been reported in which it was strongly suspected that the cause was failure of the shorting clip to make contact with the pole piece.

It is for this reason, and, bearing in mind that the inadvertent functioning of a CC detonator could have more serious consequences than with a CC igniter, that the use of shorting clips had not been recommended. In fact their use for CC igniters has also been abandoned recently.

To ensure personnel safety the filling and handling of CC detonators must be carried out under anti-static precautions behind screens and using suitably protected handling tools. It is anticipated that after manufacture at ROF Chorley the detonators will be assembled directly into the bomblet arming units, thus avoiding the need for interim storage arrangements. Nevertheless storage of detonators has been necessary during the R & D stages and could also be needed on a temporary basis at ROF (Chorley) during production. An appropriate wallet or plate has been adopted for storage or transport which will ensure that no electrostatically charged body can be discharged through the detonator. Detonators must be placed into or removed from such wallets or plates under antistatic precautions.

For the firing trials described in this memorandum the detonators were assembled onto a firing head under antistatic precautions and with the screen protection described above, and this head assembled into a small transportable firing chamber. This chamber was then removed from the anti-static laboratory, with complete safety, for firing.

4. TRIALS PROGRAMME

4.1 Details of Trials

A total of 597 detonators was received from ROF Chorley in 3 lots. To minimise any possible lot to lot variation the samples chosen for each trial were such that the ratios of the number of detonators taken from each lot to

the number in the population, was maintained.

On receipt all the detonators were inspected for varnishing faults and their individual resistances were measured and recorded. The overall distribution of resistances is shown at Fig 5. Twenty detonators, selected at random from the three lots, were radiographed to confirm that the manufacturing and filling instructions had been followed.

In all the trials the Bruceton technique (Refs 5 and 6) was adopted; detonators which failed to fire from the first pulse were destroyed by firing at successively higher energy levels but for the purposes of the statistical analysis only the reaction to the initial pulse was considered. Except where otherwise stated in the following paragraphs all firings and resistance measurements were carried out at 20 $\pm$ 2°C. The results of all trials, expressed as mean firing energies except for the direct voltage sensitivity (para 4.3.2), are given in Table 3. Also given is the mean resistance of the samples immediately prior to firing and where applicable the percentage by which this differs from the original value.

Functioning time measurements, using the flash of the detonator to trigger a photo-cell controlled timing circuit were not deemed necessary on all the firings and were measured only on the control group and the first two ISAT(B) samples; the value of this parameter was found to vary between 2.5 and 5.5 μ sec., and was not affected by ISAT(B) storage.

4.2 Control Group

Using the discharge of a 500 pF capacitor the energy sensitivity was established on a sample of 45 detonators. The charging voltage was varied to give discharge energies of 1, 2, 4, 8, 16 and 32 μJ. The results are shown graphically in Fig 6.

4.3 Comparison with N8 characteristics

4.3.1 45 Volt capacitor discharge sensitivity

In order to obtain a comparison with the energy sensitivity of the N8 igniter a sample of 45 detonators was fired from energy levels of 5, 7, 10, 18, 33 and 100 μJ obtained by charging suitable capacitors to 45 volts. The mean firing energy differed from the control group value, but this was expected as the firing conditions were not the same.

The mean energy sensitivity of the N8 igniter is typically 10-15 μJ compared to 16.5 μJ for the detonators used in this trial.

4.3.2 Direct voltage sensitivity

A Bruceton test was performed, using voltage levels of 6, 7, 8, 9 and 10 volts, on 45 detonators. The voltage was applied for 5 seconds and those detonators which failed to fire were destroyed at 30 volts.

4.4 Accelerated Storage Trials

4.4.1 ISAT(B) Life Assessment Trial

One hundred and twenty detonators of known resistance were subjected to ISAT(B) cycles. One quarter was withdrawn after 1 month, 3 months, 8 months and 18 months respectively, and tested under identical conditions to the control group (Sect 4.2).

4.4.2 Continuous Hot Storage

Twenty-five detonators of known resistance were subjected to a temperature of 100°C for one week after which the resistance was remeasured (at 100°C) and the detonators were tested under identical conditions to the control group but at a temperature of 100°C.

4.4.3 Continuous Cold Storage

Seventy-five detonators, of known resistance, were subjected to storage at -70°C. One third was withdrawn after 1 week, 4 weeks and 1 year respectively and after measurement of resistance at -70°C was tested as in Sect 4.2 but at a temperature of -70°C.

4.5 Thermal Shock

The thermal shock cycle employed was:

a. One working day at 100°C
b. Transfer to refrigerator at -70°C
c. Overnight at -70°C
d. Transfer to oven at 100°C

Thirty detonators were subjected to 20 of these cycles after which the resistances were measured and the detonators fired at a temperature of -70°C.

4.6 Vibration Trials

Sixty-four detonators were divided into 4 equal groups and vibrated as follows:

Group 1: Detonators tightly held and vibrated along the main axis of symmetry.

Group 2: Detonators tightly held and vibrated perpendicular to the main axis of symmetry.

Group 3: As for group 1 but 5 mil movement permitted in all directions.

Group 4: As for group 2 with 5 mil movement permitted in all directions.

The vibration and temperature conditions to which the detonators were subjected were:

(1) Frequency 10-40 Hz swept sinusoidally at a constant 2g peak with a sweep rate of .75 octaves/minute.

a. Ambient temperature for 100 min

b. -40°C for a further 100 min.

This followed by:

(2) Frequency 40Hz - 2KHz swept sinusoidally at a constant 7.5g peak and sweep rate 5 octaves/minute.

a. 73°C for 100 min.

b. -40°C for a further 100 min.

ie a total vibration duration of 400 min.

To ensure thermal equilibrium the detonators were held at the specified temperature for at least one hour prior to vibration. After vibration and having recorded the resistance, the detonators were fired as in Sect 4.2.

4.7 Sequential Trials

Fifty detonators of known resistance were divided into two equal groups and subjected to the following sequential trials:

Group 1
- (i) 30ft drop in 65lb block with pole piece uppermost.
- (ii) 5 thermal shock cycles as described in section 4.5
- (iii) 30 min vibration as defined by section 4.6 group 1.
- (iv) 1 week ISAT(B)

Group 2
- (i) 30 min vibration (section 4.6 group 1)
- (ii) 5 thermal shock cycles (section 4.5)
- (iii) 30ft drop in 65lb block with pole piece uppermost
- (iv) 1 week ISAT(B)

Resistance values were measured after each step in the two sequences and these values are shown in Tables 1 and 2 respectively. The two groups were fired as in section 4.2.

4.8 Drop Test

Forty-eight detonators of known resistance were divided into three equal groups. Eight detonators from each group with attitudes as follows were dropped from 30ft in the 65lb block:

Group 1: Dropped with pole piece uppermost

Group 2: Dropped with pole piece down

Group 3: Dropped with pole piece horizontal

After resistance measurement, these detonators, together with the remaining 8 from each group, were again dropped from 30ft in the 65lb block apparatus preserving the attitudes detailed above. Although large increases of resistance were recorded for detonators dropped twice none functioned inadvertently which demonstrated the detonator to be safe under 'rough handling conditions. No Bruceton test was performed and therefore the result is not given in Table 3, although all but 3 of the detonators functioned satisfactorily from a $32\mu J$ pulse derived from a 500 pF capacitor. The 3 which failed to fire had been subjected to the double drop with the pole piece uppermost, an orientation which would be the most likely to lead to movement of the conducting composition. Despite the fact that 2 of the detonators registered open-circuit on the safety ohmmeter all 3 fired at the 'destroy' level of $64\mu J$.

4.9 Explosive Performance

4.9.1 Initiation of CE stemming

In firing rigs similar to those described in Ref 8 the detonator with a 7.6 mil silver plated brass closure cup initiates a conventional low density CE stemming, through a 20 mil aluminium alloy septum over an air gap of 1.25in. Further trials are planned on receipt of new firing rigs where the detonator output will be studied at high and low temperatures using both aluminium alloy and brass stemming blocks.

On the basis of the small number tested the CC detonator compares well with the 2.25gr RWY detonator which gives initiation of the same stemming through a 25 mil aluminium alloy septum over a 0.35in air gap.

4.9.2. Shutter sealing

Detonators were functioned with an edge to edge explosive separation of 0.34in from a conventional 0.25in diameter, Class 2, CE stemming pressed at 10lb dead load, under a 12 mil aluminium alloy septum and separated from a Class 4 CE pellet, of density 1.45-1.55 $gm. cm.^{-3}$, by 0.25 in of aluminium alloy. There was no technical failure to seal.

5. ANALYSIS OF RESULTS

The results are summarised in Table 3.

Estimates of mean firing energy ($E_{50\%}$) were all obtained using the Bruceton technique; with the small samples involved this leads to a reasonable value for the mean but a relatively poor one for the standard deviation. The mean firing energies from the various tests were compared to ascertain whether any significant change had occurred.

An initial examination suggested that the results from tests Nos 6, 7, 11, 16 and 18 differed significantly from the control group mean and the reason for this was established after a careful consideration of the firing circuit.

In the early trials (Nos 1, 2, 3, 4, 5, 8, 9, 10 and 12) the transmission line connecting the firing capacitance to the detonator had an effective capacitance of about 250 pF whilst in the remainder of the trials the value was only 75 pF. This led to charge sharing and the correction factors to establish the energy at the detonator are 0.667 and 0.87 ≠ for a firing capacitance of 500 pF and firing circuits of effective capacitance of 250 pF and 75 pF respectively. These corrections are slightly overestimated as the detonator also has a small capacitance but the statistical nature of the results does not warrant a more rigorous theoretical treatment.

The results shown in Table 3 were calculated by applying these correction factors and are the energy stimuli (from a 500 pF capacitor) to produce 50% functioning. The mean values from the various tests are compared with the control group mean using the statistical significance test recommended in reference 5. and None showed any significant change in electrical sensitivity on the 5% test, defined as a 0.05 probability of obtaining this or a greater difference between the sample mean and the population (control group) mean.

Fig 6 shows the electrical stimulus vs per cent fire curve, with upper and lower 95% confidence limits, yielded by a Bruceton analysis of the control sample; it can be seen that the confidence limits, which reflect the small sample size, diverge so rapidly as to make it impossible to assign energy values to the required reliability and safety levels with any confidence. To overcome this difficulty the sample size was increased by combining the results of trials Nos 4 to 18 with those from the control group, this was justified on the grounds that there was no significant difference between their respective mean energy sensitivities. Fig 7 was produced by probit analysis of the lumped data and gives the 99.5% and 0.1% firing energies with 95% confidence as 65μ Joules and 0.1 μJoules respectively.

Although the above statistical approach has been used frequently for the analysis of the results from detonator firings it is considered that it can lead to rather higher 'all-fire' levels than are strictly necessary in a Service application. For example, 441 detonators tested at 32μ Joules or less derived from a 500 pF capacitor ((32μ J was the destroy level used in the testing programme) functioned satisfactorily. The applicability of probit analysis to EIED firing results is at present under review.

≠ Calculated as $\frac{C_1}{C_1 + C_2}$ where C_1 is the firing capacitor and C_2 the effective capacitance of the circuit.

6. CONCLUSIONS

The Detonator, Electric, CC No 1 has been subjected to the testing programme described in this memorandum; although some increases in resistance were found in all the tests these followed the normal trend for CC igniters and did not lead to significant changes in electrical sensitivity. Consequently the design is considered to be satisfactory and is offered for Service use.

The most noticeable increases in resistance were measured after the 30ft drop test, which is an indication of safety only and after which detonators are not normally expected to function. Nevertheless satisfactory functioning was obtained after the sequential trials, which included a 30ft drop stage. The only three failures to fire at 32 μ Joules occurred after the extremely vigorous double 30ft drop test and all of these detonators functioned at 64 μ joules

On the basis of the trials programme it is confidently predicted that the detonator will have an installed life of 5 years, as required in the bomblet specification (Ref 10), and this might well be considerably longer in practice. Further testing is in hand to give a more accurate prediction of the full Service life.

The firing energies quoted in this memorandum are those which actually reach the detonator terminals. In the BL755 bomblet fuze application, however, the transmission line from the piezo-crystal to the detonator may have relatively high resistive and inductive components so that it is vital that the 'all-fire' energy actually appears at the detonator terminals in a time equal to or less than about 1 microsec. This problem has been examined by EEL who have stated that the minimum delivered energy will be 64 μ Joules, which agrees closely with the 65 μ Joules quoted in section 5 necessary to guarantee a 99.5% fire level with 95% confidence.

7. ACKNOWLEDGEMENTS

The authors wish to acknowledge Mr W S Hall who contributed much to the development work described in this memorandum, and Dr R H Lynch who produced the computer programme which enabled a probit analysis of the 'lumped' data to be performed and also, in discussion, made useful contributions to a clearer understanding of significance testing.

8. REFERENCES

1. ARDE Memo (MX) 8/59 Electrical Characteristics of the N8 Igniter.
   J M Groocock and W S Hall, Feb 59.

2. RARDE Memo 7/65. The Physics and Statistics of the Electrical Initiation Process in CC Systems.
   J W Martin, April 65.

3. RARDE Publication. A Handbook for the RARDE Constant Resistance Press.
   W B Scamaton and J W Martin, Aug 64.

4. RAE Specification No WE 857.

5. Statisical Analysis for a New Procedure in Sensitivity Experiments.
   USA National Defence Research Committee Statistical Research Group, Princetown University, July 1944.

6. Unpublished R.A.R.D.E. report, 1962

7. RARDE Memo 28/68. The Sensitivity of EIED to Radio Frequency Signals.
   W L Watton and W S Hall. Sept 68.

8. RARDE Memo 26/67. Performance Data for Disruptive Detonators Pt I.
   A study of some of the design characteristics affecting performance of disruptive detonators. E A Hutton, Aug 67.

9 Electricity and Magnetism. S G Starling, P 162, 7th Ed. Aug 41.

10. RAE Specification No. WE 735.

TABLE 1

No	Resistances measured in Ohms				
	Before Trial	After Drop Test	After Thermal Shock	After Vibration	After 1 week ISAT/B
1	18.7	54.3	26.5	26.0	30
2	24.3	58.0	44	58	1100
3	24.2	35.0	37	35	71
4	21.4	46.1	43	40	580
5	23.1	38.0	39	40	150
6	26.0	32.5	33.5	33	42
7	16.3	230	68	62	720
8	25.0	17.4	18.5	18.0	20.0
9	14.0	32.7	33	33	46
10	28.7	45.1	42.5	42	410
11	23.5	33.4	34.5	33	35
12	28.7	36.1	38	37	34
13	13.8	34.6	28.0	27.0	29.0
14	22.0	29.8	29.5	27.0	26.0
15	22.4	29.2	32	29.0	29.0
16	21.7	26.6	28.0	27.0	26.0
17	19.0	24.2	26.0	24.0	24.0
18	27.7	62.0	49	50	50
19	29.0	9000	1650	1660	1500
20	21.5	135	82	78	72
21	20.2	55	42	39	35
22	19.5	43	36	42	39
23	13.4	32.4	25.0	27.0	27.0
24	22.0	65	48	48	49
25	15.1	23.3	22.5	21.0	21.0

TABLE 2

No	Resistances measured in Ohms				
	Before Trial	After Vibration Test	After Thermal Shock	After Drop Test	After 1 week ISAT/B
1	23.5	25.0	27.8	45	45
2	26.0	27.0	31.0	59	58
3	19.2	20.0	23.4	> 50k	33000
4	24.5	25.2	26.5	1000	640
5	18.4	21.5	22.5	350	186
6	26.3	28.0	30.0	599	54
7	18.8	19.2	22.0	8500	2450
8	15.5	16.0	18.4	50	48
9	18.0	18.5	20.0	46	46
10	22.0	22.6	25.2	52	46
11	18.0	19.0	20.8	45	38
12	23.2	24.0	27.4	96	104
13	29.6	31.0	34.5	340	270
14	20.0	20.8	22.4	103	90
15	17.4	18.2	19.6	33	34
16	21.5	22.5	24.5	72	72
17	28.5	29.5	32.5	160	135
18	17.7	17.7	19.0	58	56
19	16.4	17.0	18.6	36	32
20	21.5	23.0	24.6	5200	352
21	21.8	23.5	26.0	250	165
22	28.5	30.2	32.0	90	100
23	18.3	19.5	21.5	137	100
24	17.7	19.0	22.0	49	54
25	21.7	23.0	25.2	69	35

TABLE 3

Test No.	Description	$E_{50} \pm$ s.d. : J	s.c. of mean : J	Is the change signficant 5% test	Mean resistance immediately prior to test : ohms	% increase in resistance Ø
1	Control group	4.7 ± 2.0	1.2	-	22	-
2	45 volt capacitor discharge	16.5	-	-	23	-
3	D.C. sensitivity	(7.6 volts)	-	-	22	-
4	1 month ISAT/B	4.7 ± 1.8	1.2	No	23	10
5	3 month ISAT/B	4.3 ± 2.2	1.2	No	22	5
6	8 month ISAT/B	3.1 ± 2.8	1.3	No	21	5
7	18 month ISAT/B	3.7 ± 1.6	1.1	No	26	22.5
8	Continuous hot storage	5.0 ± 2.8	1.3	No	23.5	7*
9	1 week cold storage	5.3 ± 2.4	1.3	No	27.0	24.5 †
10	1 month cold storage	4.3 ± 1.5	1.1	No	29.0	21.0 †
11	1 year cold storage	2.4 ± 2.9	1.3	No	23.0	7.0 †
12	Thermal shock	4.0 ± 2.1	1.2	No	28	22
13	Vibration Gp. 1	4.9 ± 2.0	1.3	No	26.5	18
14	Vibration Gp. 2	4.9 ± 1.4	1.1	No	23.5	12
15	Vibration Gp. 3	4.9 ± 3.2	1.5	No	25	11
16	Vibration Gp. 4	2.4 ± 1.8	1.2	No	24.5	6.5
17	Sequential Gp. 1	5.2 ± 2.1	1.2	No	See Table 1	
18	Sequential Gp. 2	2.9 ± 2.7	1.3	No	See Table 2	

*Resistance measured at 100°C, compared with initial ambient temperature resistance
† As above but resistance measured at -70°C
Ø Compared to the as received population mean of 21 ohm.

 FIG. I

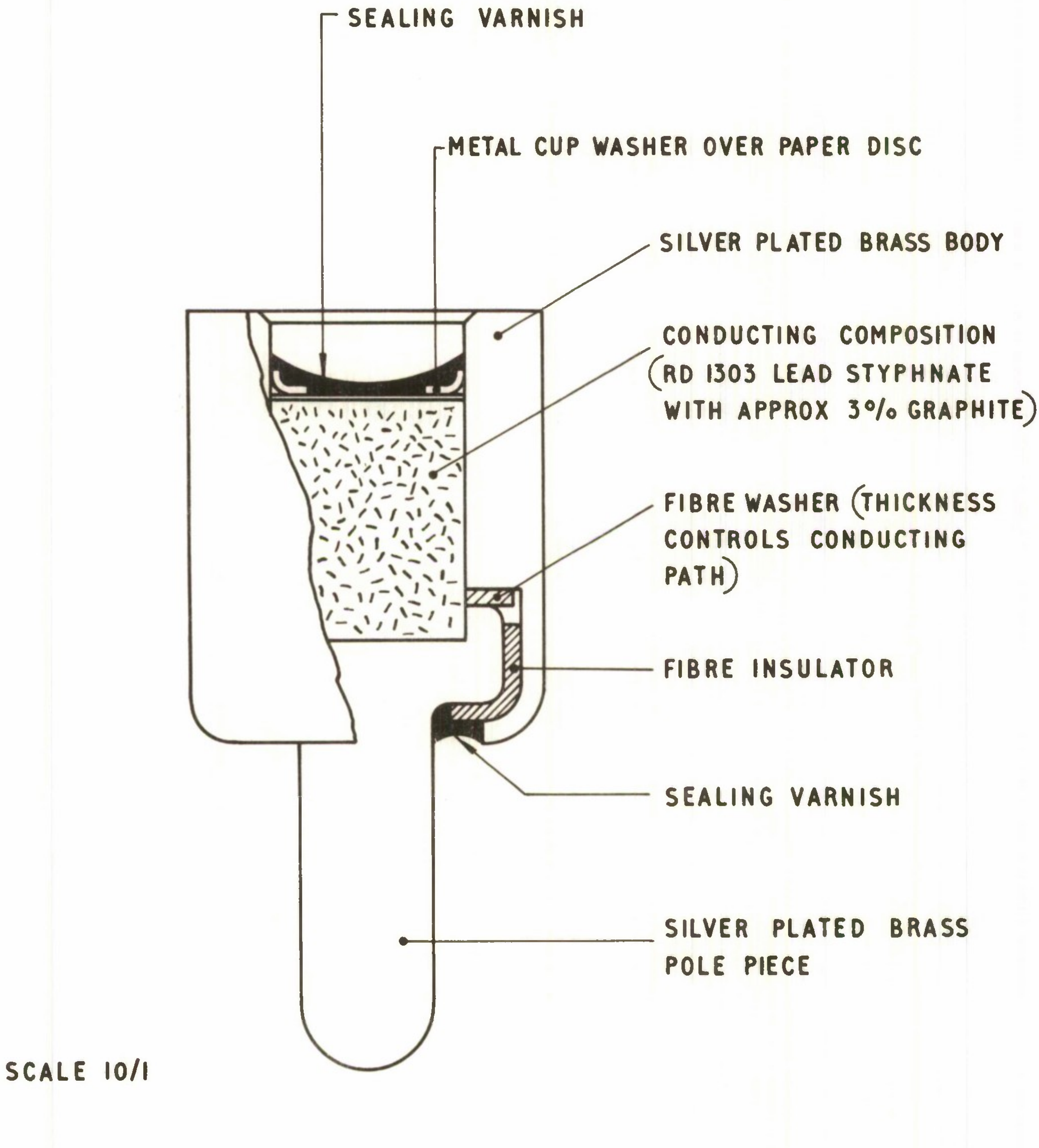
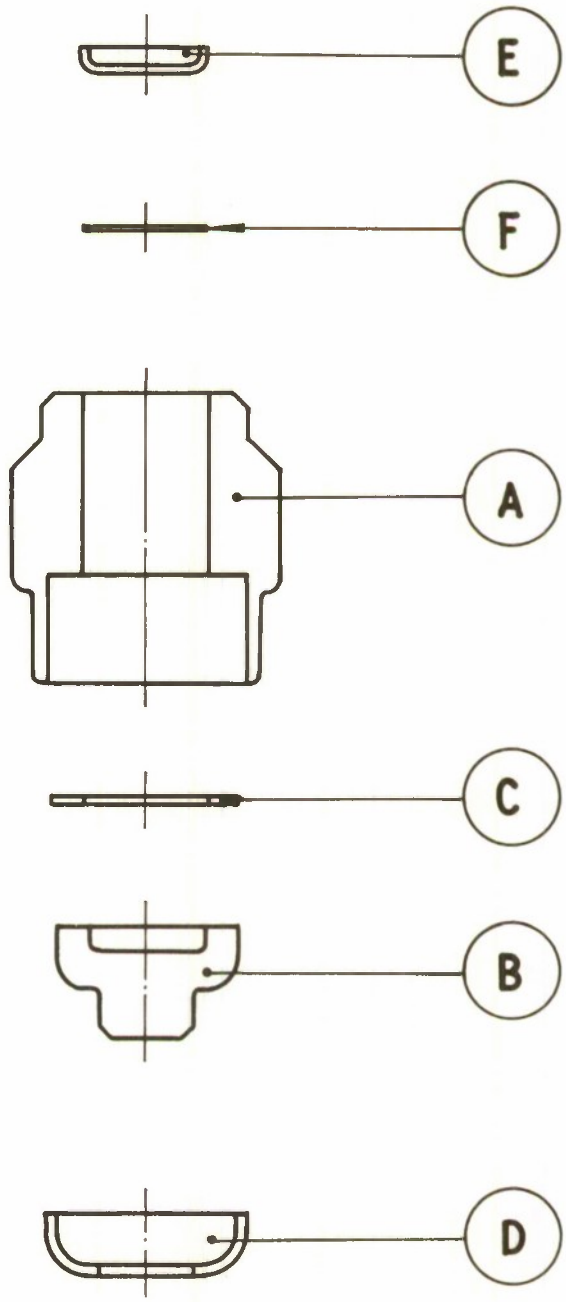


FIG.I MAIN FEATURES OF THE N8 IGNITER

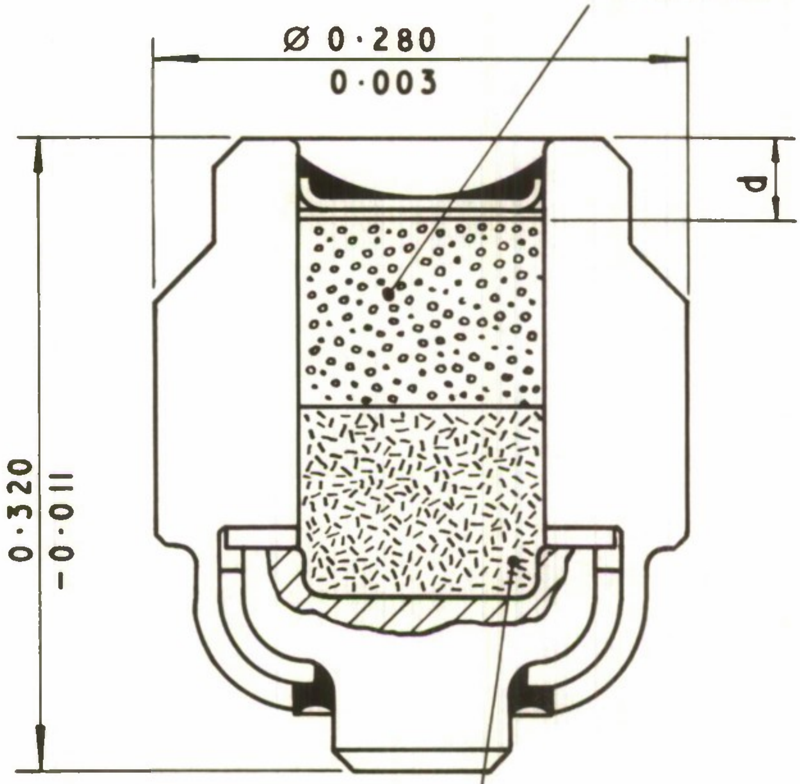
FIG.2



SCALE 5/1

FIG.2 EXPLODED VIEW SHOWING COMPONENTS OF DETONATOR ELECTRIC C.C. NO.1

RD 1347 TO SPEC. TS564
CHARGE WEIGHT 45 mg
±5 mg PRESSED TO A STOP
AT A DEAD LOAD NOT
EXCEEDING 325 lbf



RD 1339 WITH APPROX 4% GRAPHITE.
EXACT PERCENTAGE OF GRAPHITE TO BE
ADJUSTED TO GIVE CORRECT RESISTANCE
RANGE. CHARGE WEIGHT 50 mg ±5 mg
TO BE PRESSED IN UNDER A DEAD LOAD OF
325/250 lbf

SCALE 10/1

FIG. 3 FILLED DETONATOR ELECTRIC C.C. NO. 1

FIG.4

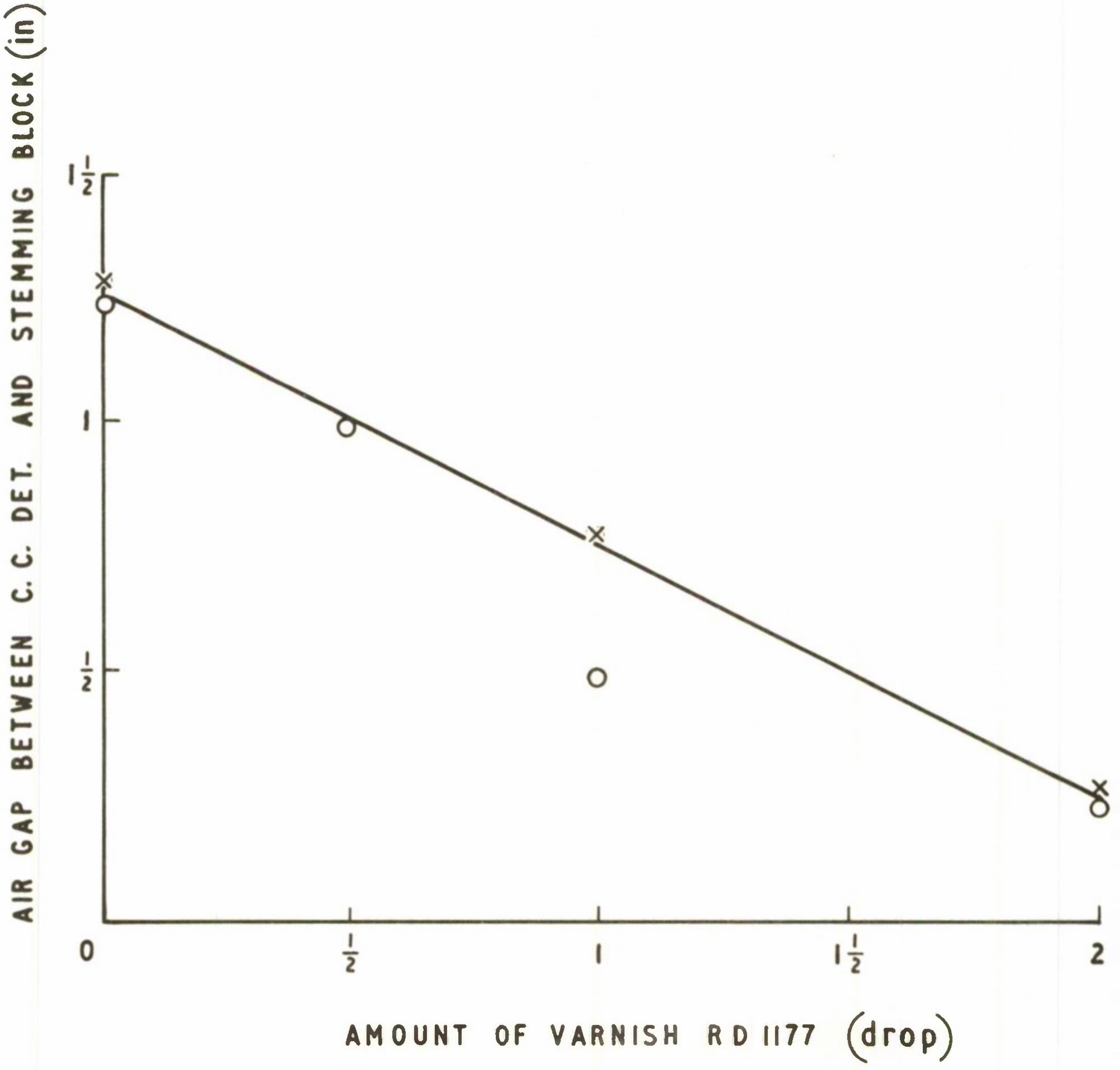


FIG.4 REDUCTION IN PERFORMANCE OF C.C. DETONATORS WITH INCREASE OF WATER PROOFING VARNISH RD 1177 TO SPECIFICATION CS 1027 WHEN USED ON SILVER PLATED BRASS CLOSING CUPS 0·009 in THICK AND FIRED AT AMBIENT TEMPERATURE, AGAINST 0·020 in THICK AL ALLOY SEPTUM OVER LOW DENSITY C.E. STEMMING

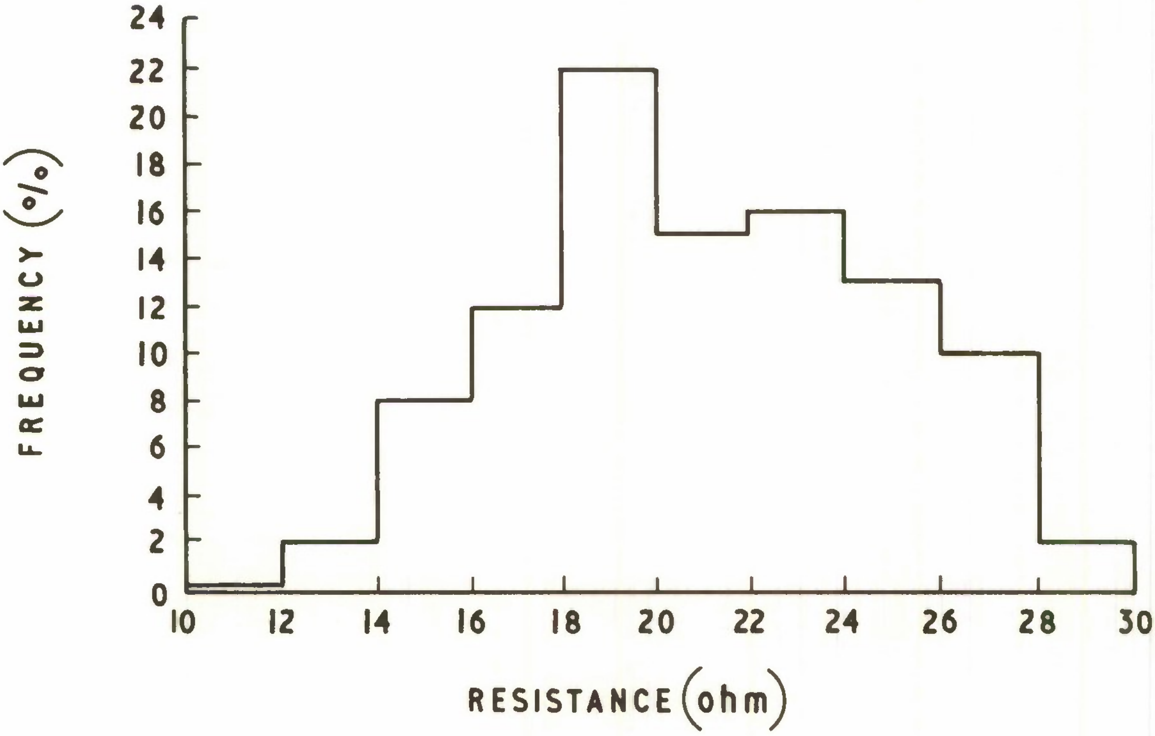


FIG. 5 DISTRIBUTION OF RESISTANCE OF THE THREE LOTS OF DETONATORS USED IN THESE TRIALS

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FIG.6

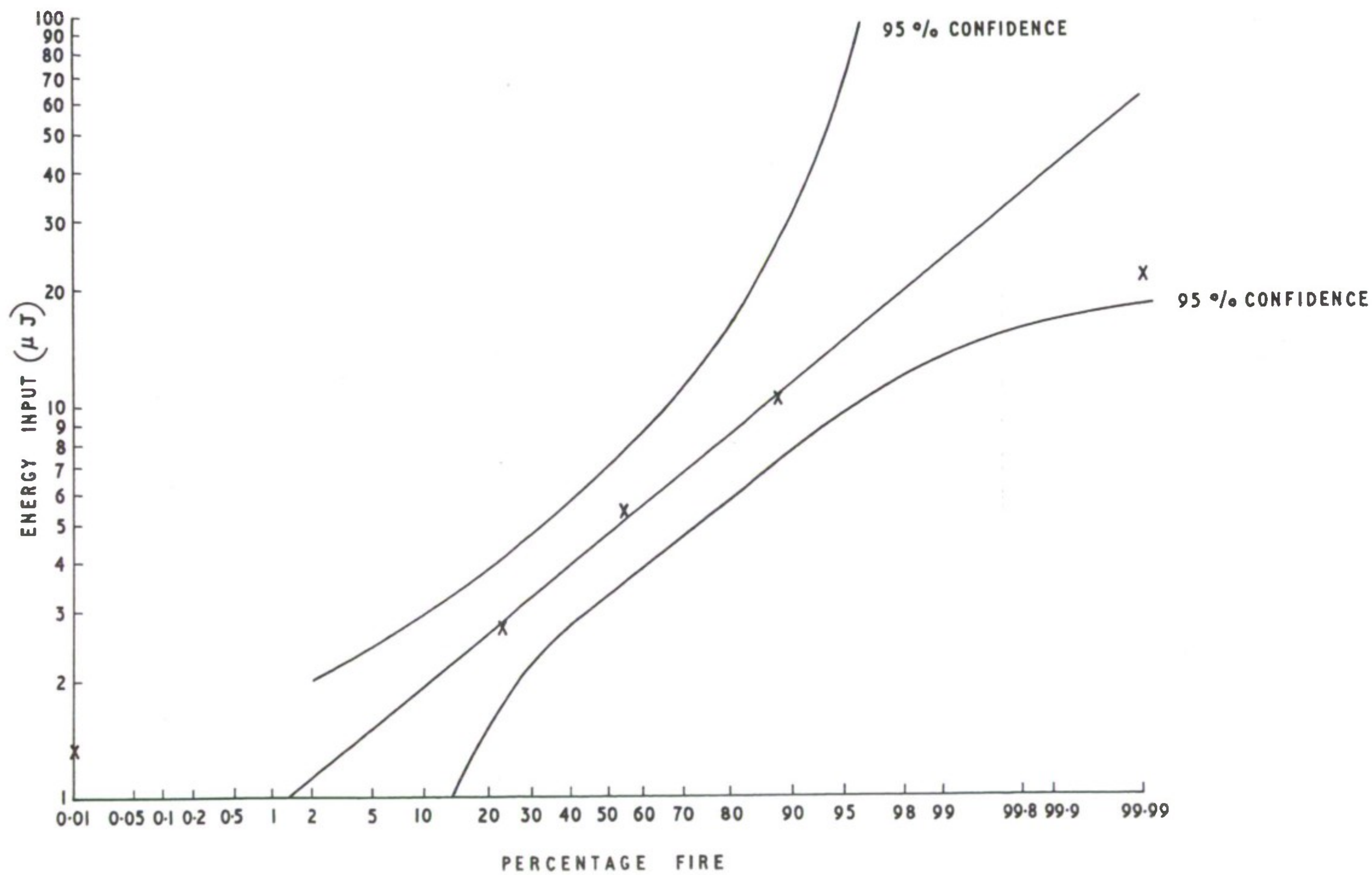

FIG. 6 ENERGY INPUT V S PERCENTAGE FIRE FOR THE CONTROL GROUP

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FIG. 7

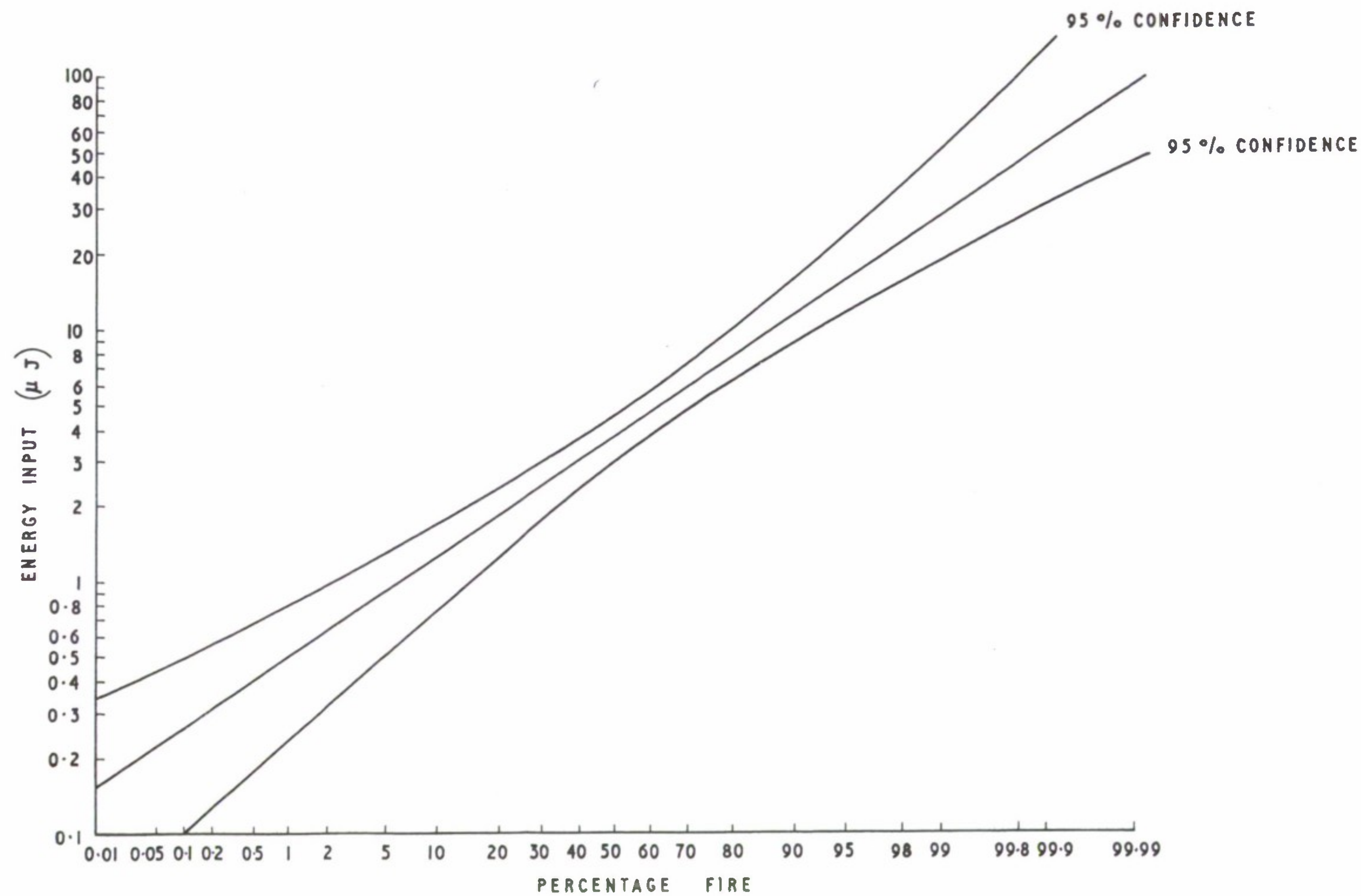

FIG.7 ENERGY INPUT VS PERCENTAGE FIRE FOR GROUPED RESULTS

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623.454.242-83:
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15 pp. 7 figs. 3 tabs. 10 refs.

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